# VIOLATED ASSUMPTIONS? EXPLORING THE CHALLENGES OF A COGNITIVE ACCELERATION INTERVENTION PROGRAMME

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*This small-scale qualitative study focusses on a four-year funded science intervention programme, Let's Think Secondary Science (LTSS). LTSS is based on the Cognitive Acceleration through Science Education (CASE) approach which was adopted in the published programme Thinking Science (Adey, Shayer & Yates, 1995). Improvements in pupil attainment were attributed to the CASE approach (Adey & Shayer, 1990) and also more recently (Oliver & Venville, 2016). Shayer (1999) posits some assumptions for effective intervention using this approach, two of which are: 1. That the teachers are skilled in the CASE pedagogy and have experience of teaching formal reasoning in science and 2. The pupils have the opportunity to witness formal reasoning by their peers (Shayer, 1999). A report by Shayer, Ginsburg and Coe (2007) suggested that UK pupils' reasoning ability declined between 1975 and 2003 and this may have implications for the LTSS programme. Indications at the outset of LTSS revealed that the science teachers were reporting difficulties with the lessons from both their own and their pupils' perspectives. In order to explore the situation in more depth, this research involved the collection of interview data from the PD tutors (n=5) and project teachers (n=10). Preliminary analysis is suggesting that issues with staffing and the school environment, a lack of teacher skills in implementing the intervention in some areas of formal reasoning and limited pupil engagement affected the extent to which the CASE approach could be implemented. As a result, some of the assumptions put forward by Shayer (1999) for effective implementation of the CASE approach might not have been realised. This suggests that there is scope for further support for formal reasoning in science before pupils move into the secondary phase and a need for more focussed professional development for teachers, particularly in the area of mathematical and statistical reasoning.*

Keywords: *Cognitive development; Continuing professional development in teachers; Reasoning*

## INTRODUCTION

In 2013, an educational charity in the UK called the Let's Think Forum (LTF), was awarded funding by the grant-making charity the Education Endowment Foundation (EEF) for a four year (2013-2017) science intervention programme for secondary school pupils called Let's Think Secondary Science (LTSS). LTSS is based on the commercially published *Thinking Science* intervention programme (Adey, Shayer, & Yates, 1995) that was developed out of the original Cognitive Acceleration Through Science Education (CASE) research at King's College, London in the late 1980s and early 1990s. A number of studies have attributed improvements in pupil achievement to the CASE approach including Adey & Shayer (1990), and more recently McCormack, Finlayson & McCloughlin (2014) and Oliver & Venville (2016).

The Education Endowment Foundation describe the LTSS programme as an update to the original Thinking Science materials that includes 19 lessons instead of 30, with updated lesson materials and resources and fewer face-to-face sessions with the PD tutor than in the earlier CASE PD programmes (EEF, 2016, p.3). EEF reported other differences between CASE and LTSS which are pertinent for this study, namely that "LTSS omitted some scientific reasoning concepts that were introduced in CASE" (p.5) and had "fewer lessons per scientific reasoning concept "(p.5), both of which might have relevance for this study.

The first cohort of 25 schools embarked on the programme in September 2013 and the pupils would participate in the 19 intervention lessons across two years until July 2015. As the LTSS programme got underway, it was reported by the PD tutors that some of the science teachers were suggesting that certain lessons were too challenging, not just for the pupils, but also for them. The implications of this in terms of

the risk to the success of the LTSS programme provided the basis for this small-scale qualitative study. Some of the challenges and potential reasons behind them are explored, particularly in light of one of the

key EEF conclusions that "in many schools, individual teachers delivered fewer than the full programme of 19 lessons" (2016, p.3).

**Background to Thinking Science and the CASE approach**

The original *Thinking Science* programme (Adey, Shayer, & Yates, 1995) was designed around a suite of activities that focussed on a range of formal Piagetian reasoning patterns and followed the CASE theory approach to planning and teaching *Thinking Science* (Simon, 2002, p.73). The lessons take the place of the usual curriculum science lessons. The CASE approach was aimed at encouraging increasing levels of abstraction from the concrete to more generalised abstract thinking (Shayer, 1999). The theoretical underpinning for the approach is based on both constructivism and social constructivism and the work of Piaget, Vygotsky and Bruner (Shayer, 2003). The CASE approach was founded on a number of assumptions, two of which are pertinent to this study. The first is that the teachers delivering the lessons would be confident in their understanding and delivery of the CASE intervention model and in the use of formal reasoning patterns within their science teaching (Adey & Shayer, 1990). The second assumption is that "for each student to have a chance to benefit [from the CASE approach] they need to witness the 'successful performance' [of one or more of their peers]" (Shayer, 1999, p.897). A risk to likelihood of this second assumption is the reported decline in pupil reasoning ability in the UK between 1975 and 2003 (Shayer, Ginsburg and Coe, 2007) and this is an important consideration.

**Research questions**

To try and gain a more detailed picture for the LTSS project, this study is looking to establish the extent to which the assumptions for an effective CASE approach had been realised in LTSS by answering the following questions:

1. What was the coverage of LTSS lessons and which, if any, appeared to be unduly challenging for a. the teachers and b. the pupils and in what way?
2. What thoughts and perceptions do the PD tutors and the teachers have about the level of engagement of the pupils in the LTSS lessons?

**Methodology**

The study adopted a qualitative approach whereby the thoughts and feelings of the CPD tutors and science teachers provided an insight into their understanding of the underpinning philosophy and pedagogy of a CA approach, and how successfully they felt this had been implemented during the LTSS programme. Data were collected by a research assistant who had no previous knowledge of CA approaches but was an experienced science teacher and a PhD student. Data collection was in the form of a single face-to-face semi-structured interview that lasted for approximately thirty minutes and was digitally recorded and transcribed. Ethical approval for the project had been obtained prior to the data collection and the participants each gave their consent prior to the interviews being conducted.

Questions sought to establish the educational background and teaching experience of the participants, their experience of teaching the LTSS lessons and how they felt these had been received by the science teachers (in the case of the CPD tutors) and the pupils (in the case of the science teachers). There was a specific focus on each of the LTSS reasoning patterns and the performance of teachers during the CPD sessions and of different groups of pupils within the science classes.

**Findings**

All of the participants in this study were science graduates. Table 1 illustrates the profile of the participants with the exception of CPD tutor 5 and LTSS science teacher 3 whose details are to be confirmed. The CPD tutors' teaching experience ranged from 10 to 26 years and all but one had experience of teaching science at A' level. The science teachers' experience ranged from 5 to 14 years and all had experience of teaching A' level science.

**Table 1: Experience of teaching different reasoning patterns to A' Level standard**

| Reasoning pattern | CPD 1 | CPD 2 | CPD 3 | CPD 4 | CPD 5 | ST 1 | ST 2 | ST 3 | ST 4 |
|---|---|---|---|---|---|---|---|---|---|
| Variables and relationships | Yes | Yes | No | Yes | TBC | Yes | Yes | TBC | Yes |
| Classification | Yes | Yes | No | Yes | TBC | Yes | Yes | TBC | Yes |
| Ratio and Proportion | Yes | Yes | No | Yes | TBC | Yes | Yes | TBC | Yes |
| Inverse ratio | Yes | No | No | Yes | TBC | Yes | Yes | TBC | Yes |
| Probability | Yes | Yes | No | No | TBC | Yes | Yes | TBC | Yes |
| Correlation and variables | Yes | Yes | No | Yes | TBC | Yes | Yes | TBC | Yes |
| Mathematical logic | Yes | Yes | No | Yes | TBC | Yes | Yes | TBC | Yes |
| Compound variables | Yes | No | No | Yes | TBC | Yes | Yes | TBC | Yes |
| Equilibria | Yes | No | No | Yes | TBC | Yes | Yes | TBC | Yes |
| Complex variables | Yes | No | No | No | TBC | Rarely | Yes | TBC | Yes |
| Formal reasoning | Yes | Yes | No | Yes | TBC | Yes | Yes | TBC | Yes |

CPD – CPD tutor; ST – LTSS science teacher

Table 2 indicates the lower levels of interest, persistence and engagement that the CPD tutors noticed in the science teachers who attended the PD. Classification was the only reasoning pattern that showed consistently high levels of science teacher engagement in the PD sessions.

| CPD tutor | Low interest | Low persistence | Low collaboration |
|---|---|---|---|
| **1** | Ratio and proportion | Ratio and proportion | Ratio and proportion |
| | Inverse ratio and proportion | Inverse ratio and proportion | Inverse ratio and proportion |
| | Equilibria | Equilibra | Equilibria |
| | Mathematical logic | Mathematical logic | |
| | Probability | | |
| **2** | Inverse ratio and proportion | Inverse ratio and proportion | Inverse ratio and proportion |
| | Probability | Probability | Probability |
| **3** | | | |
| **4** | Variables and relationships | Variables and relationships | Variables and relationships |
| | Ratio and proportion | Ratio and proportion | Ratio and proportion |
| | Inverse ratio & proportion | Inverse ratio & proportion | Inverse ratio & proportion |
| | Probability | Probability | Probability |
| | Correlation and variables | | |
| **5** | Ratio and proportion | Ratio and proportion | Ratio and proportion |

In contrast to science teacher engagement, levels of pupil engagement with the LTSS lessons was reported by the science teachers and is shown in Table 3.

**Table 3: Pupil levels of engagement with reasoning patterns in LTSS lessons**

| Science teacher | Most engaged with reasoning patterns | Least engaged with reasoning patterns |
|---|---|---|
| **1** | Variables and classification | Probability |
| **2** | Classification | Any that required mathematical reasoning |
| **3** | Classification | Mathematical logic, ratio and proportion, inverse ratio and proportion |
| **4** | Classification<br>Probability | Mathematical logic, equilibria, and ratio (for the lower ability pupils) |

PD tutors were invited to give their opinions about the LTSS materials, and the PD sessions. Table 4 gives an overview and general consensus (n= 4 or 5) of the views.

**Table 4: CPD tutor reactions to the LTSS materials, CPD sessions and participants**

| Positives | Challenges |
|---|---|
| Teachers with high levels of personal confidence who were willing to take on challenges and work through them were an attribute to the CPD sessions and to the implementation of LTSS in schools. | When teachers were unable to understand the reasoning patterns and how the tasks related to them. There were further challenges when the teachers were not able to articulate their thinking. |
| Teachers collaboration on tasks and on lesson planning benefitted in terms of their developing understanding and pedagogical awareness. | Teachers who withdrew from CPD activities because they lacked understanding and were "scared" to contribute their ideas. |
| Teachers with strong classroom management skills were able to manage the pupils' engagement in the tasks. They often took the lead during the CPD sessions and helped to facilitate others' learning. These teachers needed less scaffolding by the CPD tutors. | Teachers with weaker classroom management skills, or those unfamiliar to the pupils, struggled to engage with the lessons on any more than a superficial level and often did not get to the *reasoning* purpose of the lesson. |
| CPD tutors felt that the lesson materials were a significant improvement on earlier 'Thinking Science' materials although there was an overemphasis on the use of PowerPoint slides. | The teacher guidance materials lacked the theoretical underpinning of the earlier 'Thinking Science' materials and this led to some teachers "jumping through hoops" in order to deliver content and not using it as a means to develop pupils' reasoning. PD tutors felt that teachers would have preferred an "off the shelf" package that did not require any additional planning. |
| Where CPD tutors modelled lessons in school they felt that they made an impact on the teachers' understanding. Time and opportunity for this was limited within the project design, though. | Even when CPD tutors were flexible and able to offer more time, sometimes capacity and opportunity in school was limited and this level of support did not take place. |

**Discussion and next steps**

Although the original Thinking Science intervention programme and CASE approach has recently been replicated in Australia (Oliver, 2016) and Ireland (McCormack, 2014), the challenges experienced by the LTSS project in the UK cannot be disregarded. There appear to be implications for the appropriateness of the LTSS intervention in UK classrooms where the level of reasoning is found to be too challenging for the pupils in the class and the general decline in reasoning ability (Shayer, Ginsburg and Coe, 2007) might be contributing to this. There may be scope for further work to explore the demand for additional support for pupils' thinking in science before they leave the primary phase if this is the case. This, coupled with the instances of a lack of teacher confidence and skills in initiating higher levels of abstraction relating to mathematical and statistical reasoning suggests there is scope for more focussed professional development for science teachers to better support them in engaging fully with the CASE intervention model.

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